

ZIMBABWE'S AGRICULTURAL REVOLUTION REVISITED

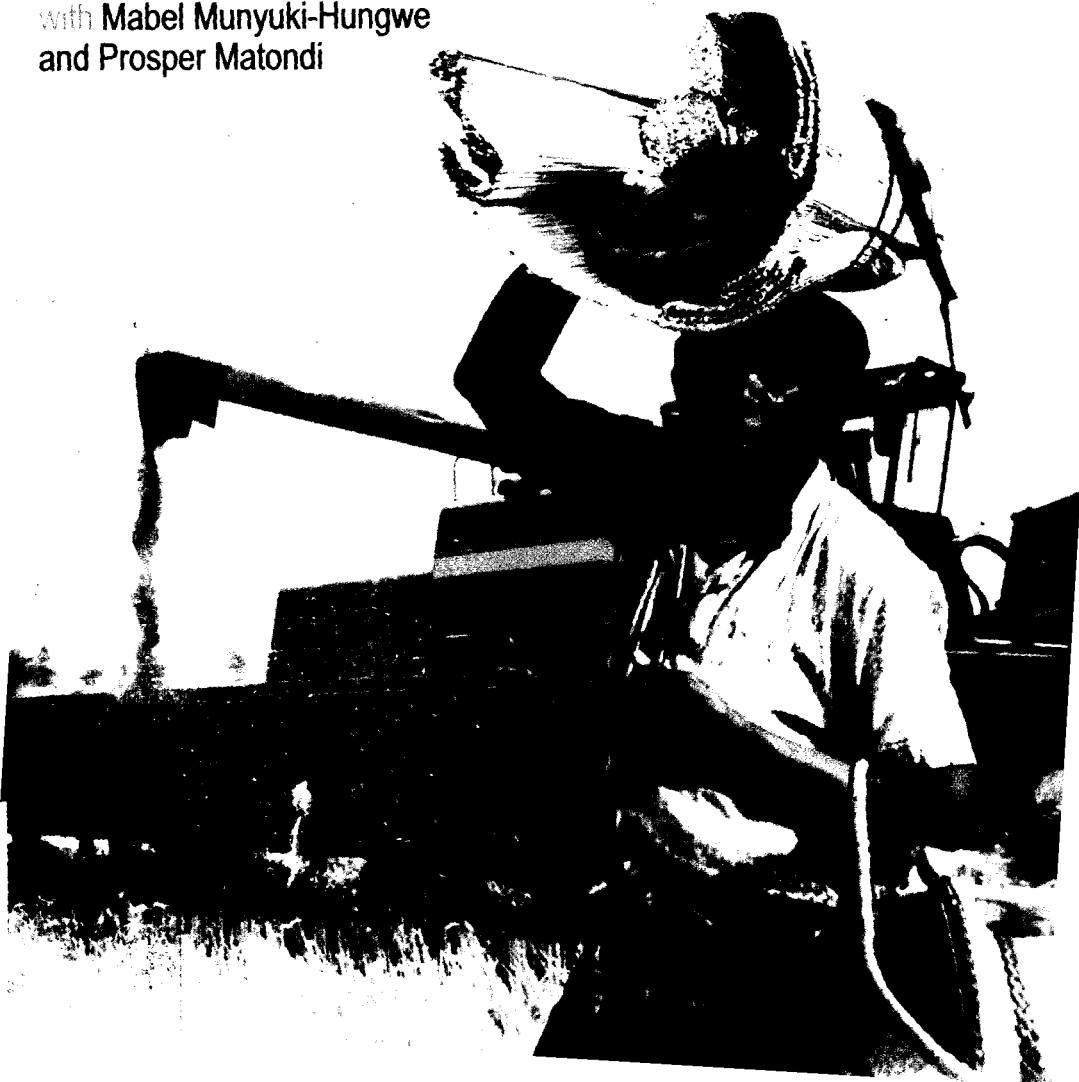
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Biotechnology offers an alternative science to agriculture

Biotechnology and the future of agriculture in Zimbabwe: strategic issues

Idah Sithole-Niang

Biotechnology is a collection of scientific disciplines that integrate natural, life and engineering sciences. The broad definition of biotechnology is simply the industrial use of living organisms or parts of living organisms to produce food, drugs or other products. Traditional biotechnology includes fermentation and the use of tissue culture in plant and animal breeding. Fermentation is used in the processes of making bread, beer, wine and cheese. Plant breeding employs vegetative, micro-propagation and tissue culture, while animal breeding uses techniques such as artificial insemination, super-ovulation and embryo transfer. Modern biotechnology permits the transfer of genes among species regardless of origin, resulting in an organism with an entirely new combination of properties (Marvier, 2001). Other definitions of modern biotechnology include specific techniques such as marker-assisted selection used in both animal and plant breeding.

Traditional biotechnology has existed in Zimbabwe since the early 1970s but modern biotechnology (molecular biology, genetic engineering or gene modification) has only been in practice in the last decade. In the context of increasing human population, agricultural researchers have to develop new technologies that will help achieve increased agricultural productivity. Agricultural biotechnology could be of benefit to a broad range of large-scale commercial and smallholder farmers. There are examples from developing countries of successful adoption of biotechnology by smallholder farmers (Gregory, Stewart and Starvrou, 2002; Kirsten and Gouse, 2003). This chapter focuses on the role of biotechnology in the agricultural sector in Zimbabwe.

Global and African overview

Development of genetic engineering technology has made significant progress in crop production but some countries have responded negatively to its use. Principal concerns relate to the safety of genetically modified crops for people and the environment, and conflict with other production systems (for example, organic systems, through gene transfer from adjacent genetically modified crops) and commercial systems. The tendency of genetically modified production to

place ownership of the means of food production in the hands of a few multinationals is controversial. There is considerable sentiment against the technology arising from the fact that it locks people's livelihoods in with profit-making multinational and global corporations. Multinational companies have merged to become huge conglomerates that threaten the seed sector throughout the world. Genetically modified crops fall within the discourse on globalization which some developing nations view as a new form of imperialism or colonization. The issue of globalization seems to have little to do with the new technology although this has become the perfect conduit for anti-genetically modified organism sentiments. The conflicts between developed and developing countries on the value of genetically modified crops to society have focused on the perceived difference in production and the food security problems that constantly face developing nations. Therefore, genetically modified crops are seen as the perfect answer to such food security challenges. The fact that food produced using this method from the United States of America dominates world food relief gives credence to the view that genetically modified crops may offer better alternatives to conventional food production.

Global overview

Globally, the area planted to genetically modified crops exceeded 81 million hectares in 2004 (James, 2004). The leading countries in terms of area planted were the United States of America, Argentina, Canada, Brazil, China, Paraguay, India and South Africa. In the United States of America, there is a favourable regulatory environment that has allowed genetically modified crops to move quickly into the field. On the other hand, European countries are still engaged in debates on the use of the new technology. Public acceptance and the need to label foods derived from genetically modified crops continue to be controversial issues across the globe. The shift from input traits to output traits is expected to be more pronounced, with farmers realizing an increased value for their crops. The requirement to test genetically modified crops before release is being institutionalized in order to safeguard human health, animal health and the environment.

Genetically modified crops in developed countries include those expressing tolerance to herbicides such as glyphosate, insect tolerance using toxic proteins derived from a soil bacterium, *Bacillus thuringiensis*, in maize and cotton, and virus resistance in papaya, squash and tomatoes. There are examples of crops with resistance to bacterial and fungal pathogens as well. Golden rice represents a different class of these engineered crops in that pro-vitamin A is an output trait. Experimentation by various research institutes continues on various types of genetically modified crops as nutritional genomics (Della Penna, 1999). Furthermore these new products will be beneficial to consumers, farmers and the industry.

Table 29.1. Value of recombinant proteins from transgenic animals

Recombinant protein	Transgenic animal	Transgenic process	Value/animal/yr (US\$)
AAT	Sheep	AAT = alpha 1-antitrypsin, inherited deficiency leads to emphysema	15,000
tPA	Goat	TPA = Tissue plasminogen activator, treatment for blood clots	75,000
Factor VIII	Sheep	Factors VII, IX = blood clotting factors, treatment for haemophilia	37,000
Factor IX	Sheep		20,000
Haemoglobin	Pig	Haemoglobin = blood substitute for human transfusion	3,000
Lactoferrin	Cow	Lactoferrin = infant formula additive	20,000
CFTR	Sheep, mouse	CFTR = Cystic fibrosis transmembrane regulator, treatment for cystic fibrosis	75,000
Human Protein C	Pig	Human protein C = anti-coagulant, treatment for blood clots	1,000,000

Source: Betsch and Webber (1995)

The transgenic animals industry has led in the cloning of genetically modified pigs where a gene responsible for transplant rejection has been deleted. PPL Therapeutics, the company that was created to commercialize the cloning techniques developed at the Roslin Institute in Scotland, is one of two companies that successfully cloned the pigs. It is envisaged that in future other transgenic pigs will be created as research on xeno-transplants takes centre stage. A list of some transgenic animals currently on the market is provided in table 29.1.

While research has been done in genetic engineering of plants and animals to produce genetically modified organisms in developed countries, some independent scientists, respecting the precautionary principle, recommend that widespread use should be restricted. An independent panel on genetically modified crops said:

'Genetically modified crops have failed to deliver the promised benefits and are posing escalating problems on farms. Transgenic contamination is now

widely acknowledged to be unavoidable and hence there can be no co-existence of genetically modified and non-genetically modified agriculture. Most important of all, genetically modified crops have not been proved safe. On the contrary, sufficient evidence has emerged to raise safety concerns that, if ignored, could result in irreversible damage to health and the environment. Genetically modified crops should therefore be firmly rejected now.'

Although countries could be covered by a new legally-binding treaty that came into force on 11 September 2003, the United States of America did not sign this Biosafety Protocol.

African overview

While data on research capacity is lacking in some African countries, the presence of a biosafety regulatory framework within countries is often a fairly good indicator of the level of biotechnology activities. Due to the lack of human resources, African governments generally do not invest in this area until a product comes in from outside, as was the case for Zambia with the introduction of transgenic cotton and Egypt when it sought collaboration with the United States Agency for International Development under the agricultural biotechnology support programme. Part of this effort has helped Egypt put five transgenic crops (tomato, maize, cotton, squash and potato) in the field for socio-economic impact assessment (Brenner, 2004).

The backlash in Europe against genetically modified crops has certainly not helped many African countries, as Europe is their major trading partner. The African Agency for Biotechnology in Algeria has established biotechnology networks. Furthermore, research activities have increased in West Africa on various options in the use of genetic modification (Alhanson, 2003). Some countries, such as Senegal, have commenced research on biological nitrogen fixation technology and used tissue culture for the micro-propagation of indigenous tree species. The Cote d'Ivoire has done research on tuber crops such as cassava and yam. In Nigeria the government has established a biotechnology agency to streamline biotechnology activities in the country in view of the controversies that face the industry. The University of Nigeria has the African Biosciences Network dealing with the genetic improvement of crops, farm animals and disease control using new vaccines. The major aim of the network is to increase African capacity to research on genetic modification rather than to accept research results from the north.

In East Africa, both Kenya and Uganda have regulatory frameworks in place. The two countries have highly developed traditional biotechnology sectors for both crops and livestock. Kenya in 2003/04 commenced field-testing transgenic virus-resistant sweet potato and developed transgenic maize that is insecticidal to stem borer (Wafula, Cohen and Wanyangu, 2004). This work

was carried out in collaboration with the International Maize and Wheat Improvement Centre in Mexico. A maize project funded by the Dutch government used marker-assisted breeding to confer drought tolerance and insect resistance. Other projects involved development of recombinant vaccines against caprine pox and rinderpest, embryo transfer and disease diagnostics (Mugabe, Kimeri-Mbote and Odame, 2000). The Uganda government agreed to fund transgenic research for five years on black sigatoka disease, weevil and nematode resistance in bananas (DeVries and Toenniessen, 2002). Ethiopia was involved in the micro-propagation of forest trees, tissue culture on tef and carried out research on biofertilizers and nitrogen fixation. The livestock industry in Ethiopia conducted some experimentation on vaccine development and disease diagnosis.

In Tanzania, the use of tissue culture for mass propagation and provision of disease-free planting materials for bananas, cashew nut and sweet potato is prevalent. Neither Tanzania nor Ethiopia have regulatory frameworks in place but these are being developed through collaborative research with the Swedish-funded Bio-EARN project that is involved in building capacity in both biotechnology and biosafety.

Southern Africa

In southern Africa, South Africa took leadership in agricultural biotechnology research followed by Zimbabwe and to a limited extent by Namibia, Zambia and Malawi. In South Africa, agricultural biotechnology activities began in the mid-1970s when plant tissue culture techniques were used, while genetic modification was introduced a decade later. The agricultural biotechnology sector is the second largest after the medical and pharmaceutical sector. South Africa has high research capacity because of large investments in technical and financial teams due to infrastructural resource capacity. There are well over 500 biotechnology projects underway in South Africa. This investment is targeted for markets in sub-Saharan Africa and other trading regions. Such an approach has the added advantage of ensuring that the quality of product developed will be of export quality. Concurrent with this development in South Africa is the growth in other business sectors such as information technology, telecommunication and banking. South Africa has also offered opportunities for students to train in biotechnology and the training offered is cost effective and of a high standard. South Africa has conducted well over 350 field tests and commercialized four transgenic products. It represents the first country in the world to carry out a socio-economic impact assessment for a transgenic crop grown by small-scale farmers (Ismael, Bennett and Morse, 2001). South Africa has hosted a number of training initiatives in biosafety and public awareness.

Application of biotechnology in Zimbabwe

Crops

Tissue culture is being used in Zimbabwe for the transformation of cassava (*Manihot esculanta*), tobacco, maize and the provision of pathogen-free planting material for sweet potato (*Ipomoea batatas*). The provision of pathogen-free sweet potato planting materials is an ongoing activity at the Biotechnology Research Institute in collaboration with the Tobacco Research Board using funding from the Biotechnology Trust of Zimbabwe. The legume inoculant factory at the Grasslands Research Station in Marondera produces rhizobium inoculants. This facility was used largely by commercial farmers in the past but smallholder farmers also benefited from its work. This initiative by the Biotechnology Trust of Zimbabwe in collaboration with the University of Zimbabwe's Department of Soil Sciences was aimed at improving smallholder crop production. The Horticultural Research Institute, also located at Marondera, is involved in tissue culture of vegetable and ornamental crops such as sweet potato and cut flowers, while private companies, such as Bluedale Enterprises, use the tissue culture technology to generate disease-free planting materials for Irish potato, sweet potato, banana, strawberry and roses.

The Biotechnology Research Institute, in collaboration with the International Maize and Wheat Improvement Centre, has been developing both insect-resistant and drought-tolerant maize using marker-assisted selection. The University of Zimbabwe's Department of Crop Science also identified markers that are linked to the *Striga asiatica* resistant trait in sorghum. The Department of Biochemistry and the Institute of Food, Nutrition and Family Science have done research on fermentation in the use of sorghum and indigenous fruits in the preparation of weaning foods and traditional beverages. They characterized micro-organisms for use as starter cultures in the fermentation of milk at the village level. The Department of Biochemistry is involved in isolating lipases, melanin and lectins from indigenous trees for use in industry and diagnostics. Research work is also ongoing on the treatment of industrial effluent. The genetic improvement of cowpea to confer both virus and herbicide tolerance has been done including the molecular characterization of the flavonoid pathway in sorghum in order to improve its milling qualities and usefulness as livestock feed.

The Department of Applied Biology and Biochemistry at the National University of Science and Technology in Bulawayo has conducted research on lipases, lectins and indigenous fungi. The Agronomy Institute in the Department of Agricultural Research and Extension has used biological pests to control the water hyacinth in Lake Chivero. All in all, several institutions are active in biotechnology research in Zimbabwe (Sithole-Niang and Mugwagwa, 2000; Sithole-Niang, 2001).

Livestock

Traditional biotechnology has had a noticeable impact on Zimbabwe's agriculture, not only on crops but in the livestock sector as well. Biotechnology is used in the dairy industry to manufacture local cheeses and in breeding through the use of artificial insemination, embryo transfers, embryo cryopreservation and *in-vitro* embryo production to develop both élite and indigenous breeds. The early cases of using biotechnology in the livestock industry in Zimbabwe date back to 1909 when attenuated vaccines were first made locally. Since 2000 biotechnology has been used in the culture of animal pathogens and the production of recombinant antigens for diagnostics. The Biotechnology Trust of Zimbabwe funded two projects on livestock improvement: one on molecular diagnostics of cattle reproductive diseases where farmers were taught how to recognize disease symptoms at the point of care, and the other on livestock feeding strategies, silage making and forage production. The project on disease diagnosis and detection was collaborative with small-scale farmers in Hwedza and Buhera districts and the Central Veterinary Laboratory. Research on nutrition was carried out in collaboration with scientists at the Grasslands Research Station and at Africa University.

Biopharming is the largest growing sector in biotechnology product development. Pharming is the production of human pharmaceuticals in transgenic animals. The technology dates back to 1982 when the first transgenic mouse was made. This produced the tissue plasminogen activator (tPA). The use of recombinant products such as recombinant bovine growth hormone (also known as bovine somatotropin – bST) sparked controversy with dairy farmers in the mid-western states of the United States of America. However, on the contrary, the use of pharmaceuticals produced as recombinant proteins did not attract much controversy. In Zimbabwe, research was conducted in the early 1990s at Henderson Research Station to test the efficacy of the recombinant hormone on indigenous breeds (Phipps, Madakadze, Mutsvangwa, Hard and de Kerchove, 1991). Milk yields were increased from 226kg for the control animals to 993kg for the treated cows. The recombinant bovine somatotropin did not only increase the milk yields but it also prolonged the period of lactation in indigenous Mashona cattle. This could be a breakthrough because the breed is well known for its low milk yields and short lactation periods. Clearly, from the Zimbabwean perspective, it would be more beneficial to extend these trials to small-scale farmers and also ensure that an efficient and workable marketing system is in place to absorb the increased milk yields. However, there is need to carry out thorough assessment through participatory research to establish whether Zimbabweans accept the concept of enhancing milk yields using recombinant bovine somatotropin.

Forestry

Zimbabwe's forests and woodlands are being deforested at an alarming rate with estimates as high as 100,000 hectares per year being cited in the *Science and technology policy document*. Pines and eucalyptus are grown on commercial plantations and grow faster, yet the exotic trees have the drawback of using a lot of underground water and are not durable in tropical climates. On the other hand, indigenous hardwoods like mukwa and mahogany have long maturation times. Although a range of biotechnological tools are now widely available, very few of these have been applied to forestry improvement. Limited funding and a lack of capacity in both human resources and infrastructure are often cited as major constraints to biotechnology development in the forestry sector. The size of the industry in Zimbabwe is rather limited, while pressure from environmentalists opposed to genetic modification is already mounting and gaining ground. This resistance is threatening to hinder forestry certification, leaving researchers in a dilemma as to whether genetic modification in particular could be used to improve forestry products in Zimbabwe. However, macro-propagation and micro-propagation have played a major role in the maintenance of both plantation and some indigenous tree species. The use of molecular deoxyribonucleic acid (DNA) markers could aid in a wide variety of applications, such as in selection, crossing and identification. Technology for conferring resistance against termites could improve forest production.

Fisheries

Zimbabwe has 114 indigenous fish species and 30 exotic species that have been introduced over time. The largest fishery is at Lake Kariba. The country produces about 25,000 tonnes of fish per year and less than a thousand tonnes is exported. Aquaculture is also present on a limited scale, with commercial fish farming occurring in tanks and ponds to produce trout, bream, carp and prawns. Most of the research effort has been devoted to fish nutrition, disease control, fish recruitment and fish ecology. There are seven research stations that have been established in the country and these fall under the Ministry of Environment and Tourism, although some of the research on aquaculture of *tilapia* is also ongoing at Henderson Research Station which falls under the Ministry of Agriculture and Rural Development. Future research needs have been identified in the areas of pathology, species selection and pond ecology. These are areas that could be addressed using biotechnological tools such as marker-assisted selection, the use of molecular markers to study genetic diversity and species identification. A preliminary genetic diversity study has been initiated at the University of Zimbabwe's departments of Biological Sciences and Biochemistry in collaboration with Bindura University. The country could explore the possibility of disseminating aquaculture much more widely and also needs to develop bioremediation strategies in order to address pollution in water bodies.

Vaccines

The latest innovation in vaccine production has been the production of DNA vaccines in animals as well as the production of plant-based vaccines (Daniell, Streatfield and Wycoff, 2001; Peterson and Arntzen, 2004). With DNA vaccines the construct is transiently expressed and is finally cleared from the system after 18 months. This might mean that the animal could not be slaughtered before the window time has lapsed. Normally this kind of vaccine is given intramuscularly then the antigen presenting cells deliver it to the immune system, which then allows it to go systemic. The scientists at Heartwater Project are developing a DNA vaccine for *Cowdria ruminantium*.

Plant-based vaccines use the concept that the first line of defence is the gut mucosa and the genito-urinary tract (Peterson and Arntzen, 2004). The technology takes advantage of the fact that proteins can be expressed in plants in an immunogenic form and can be processed post-translationally to their final functional forms if necessary. The antigens can be expressed in edible parts of plants such as bananas, carrots and tomatoes and can be taken raw by children. They can be grown in the tropics and be made available at the point of source without the production and preservation costs associated with vaccines currently available or the safety concerns associated with vaccines derived from tissue culture. However the issue of the exact dose to take and the development of oral tolerance require further research. It is interesting to note that Engerex the recombinant Hepatitis B virus vaccine has been on the Zimbabwean market for years.

Policy issues

Biosafety

Biosafety refers to the safe management of modern biotechnology and responsible deployment of genetic modification processes in order to safeguard biological diversity, local livelihoods, humanity and the environment in general. This is also aimed at making genetic modification research compliant with local conditions as experimentation results differ depending on climatic regimes. Efforts to come up with a biosafety legal framework in Zimbabwe dates back to the early 1990s when it was recognized that a biosafety board could not be fully constituted without it being governed by an existing piece of legislation. The Research Act was amended in 1998 to include biotechnological aspects of research and use. Furthermore, a fully fledged Ministry of Science and Technology was established in 2005. The ministry is located in the Office of the President and the Cabinet with a mandate to develop the regulatory framework for biotechnology. Zimbabwe now has an explicit policy on biosafety (Sithole-Niang and Mugwagwa, 2000) and regulations have been gazetted

(Statutory Instrument 20/2000). A biosafety board has been set up and guidelines have been prepared to guide researchers in their various institutions. The *Science and technology policy document* has been published and contains the policy on biotechnology that highlights the need to engage in biotechnology research and development to increase Zimbabwe's capacity and capability. The document emphasizes the sovereign right of the public to be safeguarded from the deleterious effects of the science, to be informed and consulted where necessary, and to engage in dialogue on issues of ethical, social and religious concern. Zimbabwe also reviews the regulatory framework to bring it in line with the requirements of the Cartagena Protocol on Biosafety.

Food safety

'Food safety is the assurance that a food will not cause harm when it is prepared or eaten according to its intended use' (Liu and Hong, 2002). The Food and Agriculture Organization and the World Health Organization have adopted the concept of substantial equivalents as being the most appropriate and practical way to evaluate food safety in food and food ingredients derived from genetically modified organisms (FAO, 2004). This concept states that when a new food or food ingredient is substantially equivalent to an existing food, then that product can be treated in the same manner as other conventional foods in terms of safety. For genetically modified food and genetically modified derived food ingredients, therefore, it will be the product that is tested for safety rather than the process that was used to create it. It therefore means that these new foods (in terms of food safety) are going to be subjected to the same evaluations as those applied to foods derived from conventionally bred materials.

Environmental risks

There are multiple risks associated with genetic engineering on the environment. Among the known risks are the following:

- Herbicide resistance to weeds producing 'super-weeds' which require more environmentally toxic countermeasures and incur higher costs to farmers;
- Insect resistance to the Bt pesticides due to plants which express Bt toxins constantly;
- Herbicide resistant crops tend to lower yields and incur higher costs as well as increase use of herbicides with high toxicity content. Acute illness in farmworkers may lead to chronic conditions. In addition, high dosages of herbicides affect biodiversity (plants and insects) in a negative way.

Some of the environmental risks resulting from the use of genetic modification include:

- Increased invasiveness and persistence of the transgene in the environment as a result of monoculturing of genetically modified crops;

- Development of resistance in insect populations;
- Gene flow to wild relatives (out-crossing); and
- The effect on non-target organisms (Traynor and Westwood, 1999).

A number of emerging technologies are now being developed to address some of these safety concerns (Daniell, 1999; Smith *et al.*, 2000).

Intellectual property rights

Intellectual property is a collection of ideas and thoughts that are intangible until expressed in a tangible form so as to be protected from unauthorized use by someone else. Intellectual property rights are usually protected by three legal instruments, namely, patents, copyrights and trademarks. They afford the owner legal protection from unfair competition, they reward ingenuity, ensure the free flow of ideas and allow the owner to continue to improve and innovate on the creation or invention. This protection is limited in time and scope depending on the country and gives the inventor the right to ownership. In recent years intellectual property rights have assumed worldwide importance to the extent that countries have had to sign treaties and agreements in order to protect their intellectual property rights and have established organizations to oversee their application (Erbisch and Velazquez, 1998). Examples of agreements signed and organizations set up include the General Agreement on Trade and Tariffs (GATT), Trade-Related Aspects of Intellectual Property Rights (TRIPs), the World Intellectual Property Organization (WIPO) and the World Trade Organization (WTO).

Genetically modified crops contain patented genes and are therefore protected by patent law. This means that their use is controlled by private patent holders, usually the biotechnology corporations, and farmers have to pay royalties or face legal action. Contamination of crops by genetically modified pollen from patented plants transfers ownership of the plants to the patent holder. This infringes farmers' rights to grow, re-use and sell seeds produced on the farm as enshrined in the new International Treaty on Plant Genetic Resources for Food and Agriculture. Their rights and free flow of agricultural seeds and genetic resources essential for food production are undermined by intellectual property rights that restrict access.

The need to protect intellectual property, genetic resources and indigenous knowledge in Zimbabwe has been recognized and guidelines have been put forward for developing national policies and legislation (Chitsike, 2000; Hulman and Tawonezwi, 2001). A key requirement is to assess the extent to which biotechnology approaches to agricultural problems have penetrated traditional or conventional research and how this impacts on the smallholder farmer. Other policy issues that need to be considered in the development and use of biotechnology in Zimbabwe include the following:

- Public and private sector roles and partnerships;
- Socio-economic concerns such as dealing in terminator technologies that could lead to the inability of farmers to save or replant seed;
- Monitoring and regulating the traffic of genetically modified organisms as a means of ensuring adherence to safety standards;
- Labelling of genetically-modified derived food and ingredients to allow for personal food choice. The Codex Alimentarius Commission is currently working on international guidelines for labelling genetically modified foods and food ingredients. These guidelines would enable Zimbabwe to develop its own country-specific guidelines and that process is already underway; and
- Animal genetic conservation especially of the indigenous breeds that thrive in tropical Zimbabwe.

Future of biotechnology in Zimbabwe

The basic policy and legislation on biotechnology is now in place, although further refinements will be necessary. However, policy makers need to be aware of the advantages and potential risks biotechnology could introduce into agricultural productivity. Consequently, any decisions that they make must recognize the contribution that biotechnology is likely to make to the country.

Genomics

One of the key biotechnology areas for the future is genomics. This technology is driving the design and development of new crop varieties with improved growth, pest-resistance properties and superior nutritional characteristics. It is expanding our knowledge of human, plant and livestock genomes to the extent that new genes have become available that could not have been isolated before. This technology, together with bioinformatics and the use of microarrays, is expected to speed up the development of new crop varieties, livestock and diagnostic and detection procedures (Somerville and Somerville, 1999). Because of the high cost and infrastructure required for these new technologies, Zimbabwean scientists would benefit from collaboration with scientists in advanced laboratories elsewhere. The Biosciences Eastern and Central Africa Centre has already been launched under the NEPAD biosciences initiative.

Metabolic engineering (metabolomics)

Another area for the future is metabolic engineering which involves the use of recombinant DNA technology to enhance the activities of a cell by manipulating its metabolic pathways. The goal of metabolic engineering in plants is to produce transgenic crops in which the range, scope or nature of a plant's existing natural products is modified to provide economically important attributes

(Taylor, 1998). To fully exploit this technology, scientists in Zimbabwe will need to develop an improved understanding of cell metabolism and its complexity.

Strategic issues for Zimbabwe

While traditional biotechnology has made inroads into the Zimbabwean agricultural sector, modern biotechnology is still in its infancy (Sithole-Niang and Mugwagwa, 2000), yet the potential benefit from such technology requires further investigation. The problems are numerous due to lack of both financial and human resources – there is a shortage of trained personnel in the area of agricultural biotechnology. While capacity had been achieved in previous years, it has subsequently been lost as many trained personnel have left the country due to the poor economic environment. Internal movement of staff is equally disruptive and means that many projects are not carried to completion. The shortage of suitable personnel could be addressed by government and the private sector which must continually support training and employment creation in this rapidly and vastly expanding field of science. It must be recognized that biotechnology is a multifaceted science and after initial training, the scientists will continue to need further training or refresher courses in advanced laboratories, locally and internationally. Broad sectoral investment in human resources by building and retaining the critical mass is a key requirement. A vibrant biotechnology industry could absorb some of the graduates coming out of the local institutions of higher learning but Zimbabwe needs to ensure that trained professionals are remunerated adequately.

Key individuals with expertise in certain areas, such as policy, need to be engaged to craft relevant biotechnology policies based on emerging global standards. In the absence of such policies, certain technological developments will escape Zimbabwe. Zimbabwe is also a signatory to various international treaties and agreements such as the Convention on Biodiversity Conservation and so will need to comply with the requirements. For those issues that are still open to negotiation, Zimbabwe should ensure that it registers its opinion.

There is need for a concerted effort by government and local industry to invest in biotechnology, as is the case in South Africa where there is the political will for biotechnology research and development. In this regard, state support with tax relief for entrepreneurs who invest in science and technology is part of the long-term strategy. Additional funding mechanisms for research must be sought from both local and foreign investors. The development of research parks at national universities should be viewed as a possible avenue to product development. In addition, scientists are required to play a leading role in business and marketing. Multinational companies should be involved through investments in biotechnology research and development, not just through product development and marketing.

Conclusion

The benefits from agricultural biotechnology for Zimbabwe cannot be over-emphasized. A clear biotechnology policy on how best to move forward and target products that could give it a competitive advantage globally is required. The current *Science and technology policy document* falls short of that. Public awareness campaigns based on accurate information and an open and honest debate are needed. Decisions on the future of genetically modified organisms should be science-based. Scientists should take a proactive role in disseminating information in simple terms that the ordinary farmer can understand, otherwise continued ignorance on the subject will remain the greatest threat to biotechnology development in Zimbabwe.

References

- Alhassan, W. S., *Agrobiotechnology application in West and Central Africa*, IITA, Ibadan, 2003.
- Betsch, D. F. and J. Webber, *Pharmaceutical production of proteins from transgenic animals*, in Biotechnology Information Series, Office of Biotechnology, Iowa State University, Iowa, 1995.
- Brenner, C., *Telling transgenic technology tales: Lessons from the Agricultural Biotechnology Support Project*, ISAAA Briefs No. 34, International Service for the Acquisition of Agri-Biotech Applications, Nairobi, New York and Manila, 2004.
- Chitsike, L. T., 'Intellectual property rights and genetic resources: Guidelines for developing sui generis national policies and legislation to promote community and farmers' interests for southern Africa', in the proceedings of a workshop sponsored by IUCN/FAO Links Project # CGB/RAF/338/NOR, Harare, 2000.
- Cohen, J. I., 'Harnessing biotechnology for the poor: Challenges ahead for capacity building, safety and public investment', in *Journal of Human Development*, 2 (2): 239–262, 2001.
- Daniell, H., 'GM crops: Public perception and scientific solutions', in *Trends in Plant Science* 4 (12): 467–469, 1999.
- Daniell, H., S. J. Streatfield, and K. Wycoff, 'Medical molecular farming: Production of antibodies, biopharmaceuticals and edible vaccines in plants', in *Trends in Plant Science* 6 (5): 219–226, 2001.
- De Vries, J and G. Toenniessen, *Securing the harvest: Biotechnology, breeding and seed systems for African crops*, page 208, CABI Publishing, Wallingford (United Kingdom) and Cambridge (United States of America), 2002.
- Della Penna, D., 'Nutritional genomics: Manipulating micronutrients to improve human health', in *Science* 285: 375–379, 1999.

Erbisch F. H. and C. Velazquez, 'Introduction to intellectual properties', pages 3–18 in F. H. Erbisch and K. M. Maredia (eds), *Intellectual property rights in agricultural biotechnology*, CABI International, Wallingford (United Kingdom) and Cambridge (United States of America), 1998.

Food and Agriculture Organization, 'Agricultural biotechnology: Meeting the needs of the poor?' in *The state of food and agriculture 2003–2004*, Rome, 2004

Gregory, P., R. Stewart and S. Starvrou, 'Adoption of Bt cotton by small-scale farmers in South Africa', pages 31–34 in *Pesticide Outlook*, 2002.

Hulman, B. and P. Tawonezvi, 'Guidelines for development of regional and national policy on the management of farm animal genetic resources', in *Management of farm animal genetic resources in the SADC region*, SADC/UNDP/FAO Project # RAF/97/032, FAO, Pretoria, 2001.

Ismael, Y., R. Bennett and S. Morse, 'Can farmers in developing countries benefit from modern technology? Experience from Makhathini Flats, Republic of South Africa', in *Crop biotechnology brief* Vol. 1 No. 5. (<http://www.isaaa.org/kc/>), University of Reading, Reading, 2001.

James, C., *Global status of commercialized biotech/genetically modified crops: 2004*. ISAAA Briefs No 32, International Service for the Acquisition of Agri-Biotech Applications, Nairobi, New York and Manila, 2004.

Kirsten, J. and Gouse, M., 'The impact of agricultural biotechnology in South Africa', in N. Kalaitzandonakes (ed), *The economic and environmental impacts of agbiotech: A global perspective*, Kluwer-Plenum Academic Publishers, New York, 2003.

Liu, J. W. and Y. Hong, 'Food biotechnology: Science and farming working hand-in-hand', Asian Food Information Centre (www.afic.org), 2002.

Marvier, M., 'Ecology of transgenic crops: Measuring the environmental risk of genetically engineered plants is difficult', in *American Scientist* 89 (2): 160–167, 2001.

Mugabe, J., P. Kameri-Mbote and H. Odame, 'Biotechnology for food security in Africa: From rhetoric to action', *Biotechnology Policy Brief* 1 (2) 1–8, 2000.

Peterson, R. K. D. and C. J. Arntzen, 'On risk and plant-based biopharmaceuticals', in *Trends in Biotechnology*, 22:2: 64–66, 2004.

Phipps, R. H., C. Madakadze, T. Mutsvangwa, D. L. Hard, and G. de Kerchove, 'Use of bovine somatotropin in the tropics: The effect of sometribove on milk production of *Bos indicus*, dairy crossbred and *Bos taurus* cows in Zimbabwe', in *Journal of Agricultural Science*, Cambridge, 117: 257–263, 1991.

Sithole-Niang, I., 'The future of plant science in Zimbabwe', in *Trends in Plant Science*, 6 (10): 493–494, 2001.

Idah Sithole-Niang

Sithole-Niang, I. and J. Mugwagwa, 'Agricultural biotechnology assessment : sub-Saharan Africa, country-specific study – Zimbabwe', a paper prepared for the regional workshop on building national biotechnology innovation systems: 'New forms of institutional arrangements and financial mechanisms', African Centre for Technology Studies, Nairobi, 2000.

Smith, N. A., S. P. Singh, M. B. Wang, P. A. Stoutjesdijk, A. G. Green, and P. M. Waterhouse, 'Total silencing by intron-spliced hairpin RNAs', in *Nature*, 407 319-320, 2000.

Somerville, C. R. and S. Somerville, 'Plant functional genomics', in *Science* 285: 380–387, 1999.

Zimbabwe government, *Statutory Instrument 20/2000*, Harare, 2000.

Taylor, C. B., 'Factories of the future? Metabolic engineering in plants cells', in *The Plant Cell*, 10: 641–644, 1998.

Traynor, P. L. and J. H. Westwood, *Proceedings of a workshop on 'Ecological effects of pest resistance genes in managed ecosystems'*, Information Systems for Biotechnology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 1999.

Wafula, J. S., J. I. Cohen, and S. Wakhusama Wanyangu, 'Strategic technology linkages: The case of biotechnology', pages 311–337 in C. G. Ndiritu, J. K. Lynam and A. N. Mbabu (eds), *Transformation of agricultural research systems in Africa: Lessons from Kenya*, Michigan State University Press, East Lansing, 2004.

Websites

<http://www.aab.org.dz>

<http://www.biosciencesafrica.org>

http://www.fao.org/fi/fcp/FICP_ZWE_E.asp

<http://www.isaaa.org/kc/Publications/pdfs/isaaabriefs/Briefs%2031.pdf>

<http://www.i-sis.org.uk/ispr-summary.php>



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